NC STATE UNIVERSITY DEPARTMENT of SOIL SCIENCE

Nitrogen, Phosphorus, and Liming Effects of Layer Manures in Coastal Plain and Piedmont Soils

COLLEGE OF AGRICULTURE & LIFE SCIENCES ACADEMICS ▲ RESEARCH ▲ EXTENSION

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Introduction

Nutrient availability in poultry manures can vary with animal diet, manure processing, and soil type. Whereas several studies have evaluated N and P release from chicken broiler litter, there is relatively little information on layer manure N and P availability or liming effects.

Objective

To evaluate N and P availability, and liming value of three sources of chicken layer manures applied to surface samples of three North Carolina soils based on laboratory incubations and greenhouse plant growth.

Methods and Materials

- Manures: Fresh manure from a Nash Co., NC farm, composted manure from a Hyde Co., NC farm, and manure pellets from a Jackson Co., IN farm were ground, sieved and analyzed (Table 1, Figure 1).
- Soils: samples (5-15 cm depth) of three soils were collected and analyzed for selected physical and chemical characteristics (Table 2). The land uses at sampling were: Belhaven (Terric Haplosaprists), long-term crop production; Cecil (Typic Kanhapludults), pasture; and Lynchburg (Aeric Paleaquults), first crop of corn after timber harvest and forest clearing.
- N incubations: An experiment was conducted with each soil in 1 L sealable plastic bags , with a RCBD and 5 N treatments and 3 replications. All N sources (manures and urea) were applied at the rate of 133 µg total N cm^{-3} of soil (200 kg N ha^{-1}), except for the unfertilized treatment. The Lynchburg was limed to a pH of 5.6 prior to the addition of N sources (Table 2). Moisture in N-treated soil samples was maintained at 80% of water holding capacity, and 1M KCl-extractable NH_4- and NO_3-N were determined at 0, 3, 14, 30, 60 and 90 d after N application. Mineralization of N was modeled based on a two parameter exponential model [$N_t=N_0(1-e^{-kt})$].
- Lime incubations: Similar incubations were conducted with reagent grade $CaCO_3$ (3 rates), 2 rates of each manure, and an unlimed sample.
- P incubations: Similar incubations were conducted with monocalcium phosphate [$Ca(H_2PO_4)_2$] (3 rates), 2 rates of each manure, and an unamended sample.
- Greenhouse: Growth and nutrient content of browntop millet [*Urochloa ramosa* (L.) T.Q. Nguyen], and residual soil nutrient levels were measured following 30 d of plant growth in pots containing soil and either inorganic N and P, or manures (with and without inorganic P).

Table 1. Chemical properties of the manure sources.

Manure	pH	Total N	P	K	Ca	Mg	CCE	C:N
		g kg^{-1}					%	
Fresh	6.5	65	14	28	114	8	30	4.5
Compost	6.6	53	18	36	98	9	23	5.2
Pellet	6.2	37	13	28	149	8	36	6.6

Table 2. Physical and chemical properties of the soils.

Soil	C	Sand	Clay	pH H_2O	Acid Sat.	Exchangeable ECEC	Ca	Mg	K	KCl-extractable NH_4-N	NO_3-N	M3 P
	--------- % ---------				%	cmol$_c$ L^{-1}				µg cm^{-3}		
Belhaven	43	22	9	4.8	1	28	20	8	0.1	11	9	16
Cecil	1	47	12	5.8	2	5	4	1	0.3	5	1	9
Lynchburg	5	60	2	3.8	63	5	1	0.5	0.2	105	56	36

Figure 1. Fresh and composted manure sources used in this study, and a pilot scale pelletizer similar to the source used here.

Results

N Incubations

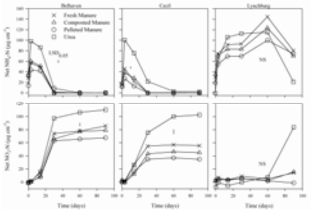


Figure 2. Net N mineralization following manure or urea application. Vertical bars represent $LSD_{0.05}$ for the N-source by time interaction effect.

Table 3. Net N mineralization.

Source	Mineralizable N	
	µg cm^{-3}	% of total N
Belhaven		
Fresh	75.2	57
Compost	70.7	53
Pellet	61.4	46
Cecil		
Fresh	54.0	41
Compost	43.6	33
Pellet	33.9	25
Lynchburg		
Fresh	110.7	83
Compost	97.0	73
Pellet	80.9	61

Lime Incubations

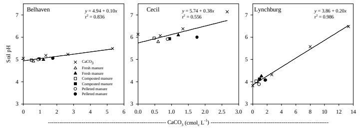
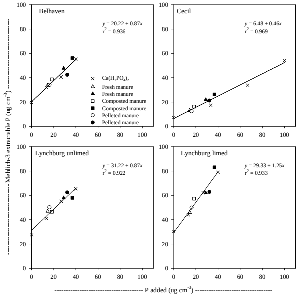


Figure 3. Soil pH following manure or $CaCO_3$ application at the indicated $CaCO_3$ equivalent rates. Regression lines are based on combined manure and $CaCO_3$ data.

P Incubations

Figure 4. Soil Mehlich-3 P, averaged across 4 sampling dates, as a function of P added following manure or $CaCO_3$ application. Regression lines are based on combined manure and monocalcium phosphate incubation data.



Greenhouse Growth

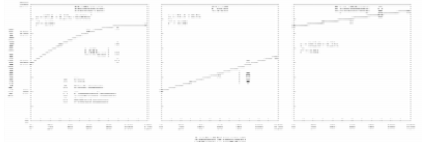


Figure 5. Amount of N in millet as a function of N applied as either urea or manure. Regression lines are based on urea treatments. Vertical bars represent $LSD_{0.05}$ among manure sources, which did not differ significantly in the Lynchburg soil.

Discussion / Conclusions

- Both manure processing and soil properties influence manure nutrient availability.
- The manure pellets released less N, and the release was slower than the other two manures (Fig. 2, Table 3). A similar relative N availability was observed with millet grown in the Belhaven and Cecil soils (Fig. 5).
- More of the total N mineralized when manures were incubated with Belhaven and Lynchburg soils than with Cecil soils, probably due to greater clay content in the Cecil soil and related surface binding or physical protection (Table 3).
- No nitrification was evident in the Lynchburg soil until after 60 d of incubation. This suggests that the low pH (3.8) of this soil resulted in initially low nitrifier populations even though it was limed prior to incubation (Fig. 2).
- Soil test pH and P changes following layer manure application were similar to changes following inorganic sources (Fig. 3,4).
- Maximum plant growth was achieved whenever N, P, and acidity constraints of each soil were corrected. Lack of significant N response in the Lynchburg soil was probably due to its higher initial inorganic N content (Fig. 5, Table 2).
- Additional research to verify standard nutrient availability assumptions (50-60% of N, 70-80% of P) is needed under field conditions and with manures that have not been ground and sieved.

Acknowledgements

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